Executive Summary

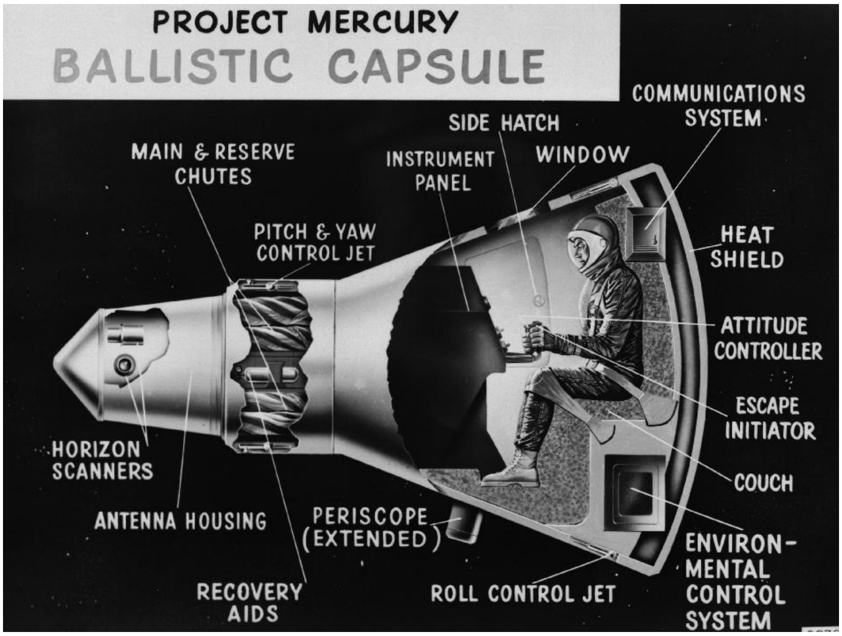
A cabin space intended for human use must keep the occupant(s) alive as well as support all the physical systems and cargo that a mission requires and accommodate the activities the crew must perform. These necessities must be balanced against volume and mass limits imposed by the capabilities of the vehicle itself. Standards in NASA-STD-3001 Volume 2 aim to ensure the crew cabin contains all necessary features to maximize crew efficiency, human performance, and mission success.

Relevant Standards

NASA-STD-3001 Volume 2, Rev C

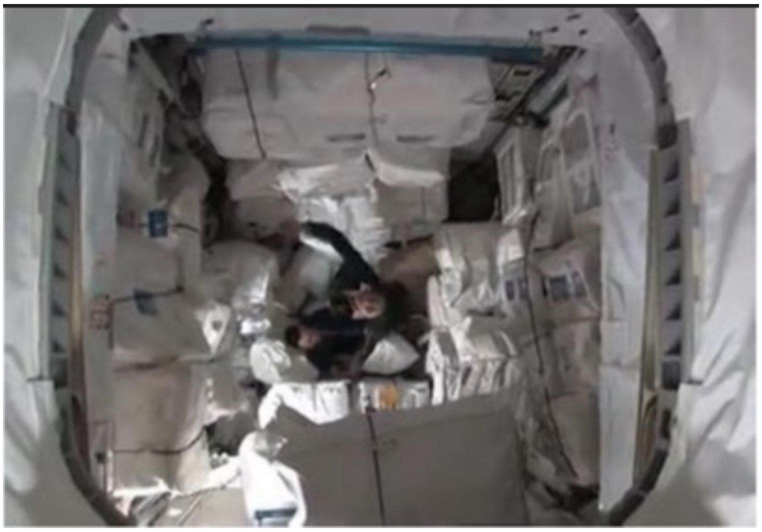
[V2 7050] Stowage Provisions
[V2 7051] Personal Stowage
[V2 7052] Stowage Location
[V2 7053] Stowage Interference
[V2 7054] Stowage Restraints
[V2 7055] Priority of Stowage Accessibility
[V2 7056] Stowage Operation without Tools
[V2 7057] Stowage Access while Suited
[V2 7058] Identification System
[V2 7064] Trash Accommodation
[V2 7065] Trash Volume Allocation
[V2 7066] Trash Stowage Interference
[V2 7069] Labeling of Hazardous Waste
[V2 8001] Volume Allocation
[V2 8005] Functional Arrangement
[V2 8006] Interference
[V2 8009] Interface Orientation
[V2 8010] Location Identifiers
[V2 8011] Location Aids
[V2 8013] Intravehicular Translation Paths
[V2 8014] Escape Translation Paths
[V2 8020] Crew Ingress/Egress Translation Path - Ground
[V2 11005] EVA Translation Path Hazard Avoidance

Background



The Mercury capsule was cramped
The capsule contained all essential systems for flight, communications, and keeping the crewmember alive. With regards to volume accommodations for crew activities, there was enough room for an astronaut to sit and operate the command console, but little else. The crew space had only 2.8 cubic meters of habitable volume, the smallest of any American crewed space vehicle.

International Space Station (ISS) crew complaints about inconvenient stowage system
"…Stowage is one area that deserves some attention, because ground doesn't really understand the problems of gathering equipment from multiple locations and tying it down for use at a work site. Walls are already cluttered, and it's hard to organize a location nearby. Most items are buried deep in bags, sometimes three or four deep. Inside a locker, there is a CTB, inside of which is a kit, which has a Ziploc with a tool inside. This can really add to the cost of doing business…"


The Leonardo Permanent Multipurpose Module (PMM), installed in March 2011, is used for storage on the ISS.

Risks
If a crew cabin space is inadequately designed, laid out, or furnished, the crew will either have difficulty performing tasks or will be unable to perform them at all. Additionally, crew discomfort can cause and aggravate reduced effectiveness. In extreme cases, improper design can endanger the crew or cause damage to the vehicle. For example, if an emergency egress path is blocked by storage containers, the crew would have difficulty escaping the vehicle.

Reference Data

Stowage

- The system must provide space to store everything the crew and mission needs. Items must be stored in a dedicated, accessible location that does not interfere with other crew tasks.

Trash

- The system must have a trash management system to deal with waste produced during the mission. Special care must be taken to ensure containment of trash and its odor.

Body Waste & Hygiene

- The system must provide space for crewmembers to perform hygiene tasks and means to safely dispose of body waste.

Crew Task Volume

- Any crewed vehicle must have enough physical space for a specified number of crew to perform all necessary tasks for the duration of the mission.

Spatial Configuration

- The spatial configuration of the cabin space must facilitate crew operations in a logical manner.

Spatial Orientation

- In a microgravity environment, the crew lacks a common "up-and-down." The system must establish a consistent orientation of interfaces and spaces.

Translation Paths

- The system must facilitate the easy and safe movement of crew and equipment through, in, and out of the vehicle.

One of two crew quarters located in the *Zvezda* module

Eating dinner on *Skylab I* (1973)

Eating dinner on the *ISS* (2015)

Application Notes

The crux of the challenge when designing a crewed cabin space is *striking the balance* between everything that the crew and mission needs, and the volume and mass limits dictated by the capabilities of the vehicle. The crew cannot get all the comforts or space they want, but engineers cannot simply design a 'windowless box' with no regard to crew needs.

ISS Astronaut using Advanced Resistive Exercise Device (ARED)

Things to consider:

What systems does the vehicle require (power, thermal, ECLSS, etc.)
- Each of these systems take up mass and volume
- They must not interfere with other cabin elements
- They must be accessible for maintenance

Consumables (food, water, air, etc.)
- Longer missions require more consumables
- Food must be stored separately and hygienically

Cargo (tools, clothes, EVA suits, etc.)
- Different missions will require different cargo, which will need to be stored and accessible

Crew (number, size, age, etc.)
- More crew will require more resources
- Crew of differing size, age, etc. will use more or less resources

Crew tasks and activities (eating, sleeping donning/doffing suits, etc.)
- Every task requires a certain amount of space
- Certain tasks should be in separate spaces (e.g., eating/waste management and hygiene)

Mission parameters (duration, destination, etc.)
- Longer and farther missions will require more resources

Skylab sleep chamber (1973)

ISS sleep chamber (2012)

Back-Up

Major Changes Between Revisions

Original → Rev A

- Updated information to be consistent with NASA-STD-3001 Volume 1 Rev B and Volume 2 Rev C.

Referenced Standards

NASA-STD-3001 Volume 2 Revision C

[V2 7050] Stowage Provisions The system shall provide for the stowage of hardware and supplies, to include location, restraint, and protection for these items.

[V2 7051] Personal Stowage The system shall provide a stowage location for personal items and clothing.

[V2 7052] Stowage Location All relocatable items, e.g., food, EVA suits, and spare parts, shall have a dedicated stowage location.

[V2 7053] Stowage Interference The system shall provide defined stowage locations that do not interfere with crew operations.

[V2 7054] Stowage Restraints The system shall provide the capability to restrain hardware, supplies, and crew personal items that are removed or deployed for use as defined by crew task analysis.

[V2 7055] Priority of Stowage Accessibility Stowage items shall be accessible in accordance with their use, with the easiest accessibility for mission-critical and most frequently used items.

[V2 7056] Stowage Operation without Tools Stowage containers and restraints shall be operable without the use of tools.

[V2 7057] Stowage Access while Suited The stowage system shall be accessible by a suited crewmember.

[V2 7058] Identification System The stowage identification system shall be compatible with the inventory management system.

[V2 7064] Trash Accommodation The system shall provide a trash management system to contain, mitigate odors, prevent release, and dispose of all expected trash.

[V2 7065] Trash Volume Allocation Trash stowage volumes shall be allocated for each mission.

[V2 7066] Trash Stowage Interference The system shall provide defined trash stowage that does not interfere with crew operations.

[V2 7069] Labeling of Hazardous Waste
The hazard response level (HRL) of all liquids, particles, gases and gels shall be labeled on the outermost containment barrier in location(s) visible to crew.

[V2 8001] Volume Allocation The system shall provide the defined habitable volume and layout to physically accommodate crew operations and living.

[V2 8005] Functional Arrangement Habitability functions shall be located based on the use of common equipment, interferences, and the sequence and compatibility of operations.

[V2 8006] Interference The system shall separate functional areas whose functions would detrimentally interfere with each other.

[V2 8007] Spatial and Interface Orientation The system shall have consistent spatial and interface orientations relative to a defined vertical orientation.

[V2 8010] Location Identifiers A standard location coding system shall be provided to uniquely identify each predefined location within the system.

[V2 8011] Location Aids The system shall provide aids to assist crewmembers in locating items or places within the system and orienting themselves in relation to those items or places.

[V2 8013] Intravehicular Translation Paths The system shall provide intravehicular activity (IVA) translation paths that allow for the safe and unencumbered movement of suited and unsuited crew and equipment.

Referenced Standards

[V2 8014] Emergency Escape Paths The system shall provide unimpeded and visible emergency escape routes commensurate with the hazard analyses and response concepts.

[V2 8020] Assisted Ingress and Egress Translation Path The system shall provide translation paths that accommodate the ingress and egress of a crewmember assisted by another crewmember.

[V2 11005] EVA Translation Path Hazard Avoidance EVA translation paths shall be free from hazards.

Reference List

1. Human Integration Design Handbook (HIDH). (2014). NASA/SP-2010-3407/REV1. https://www.nasa.gov/sites/default/files/atoms/files/human_integration_design_handbook_revision_1.pdf
2. Stuster, J. (2010). Behavioral Issues Associated with Long-Duration Space Expeditions: Review and Analysis of Astronaut Journals Experiment 01-E104 (Journals): Final Report. *NASA/TM-2010-216130*. https://lsda.jsc.nasa.gov/lsda_data/dataset_inv_data/ILSRA_2001_104__1740256372_.pdf_Expedition_8_ILSRA-2001-104_2011_31_010100.pdf